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Quantifying the Effects of an Active Learning Strategy on the Motivation of Students*

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The main objective of this paper is to quantify the effects of an active learning strategy on the motivation of students in a process control course. In the first part of the investigation, the relative performance of students was used as a tool to gauge the effects of the active learning strategy on the motivation of students. The results indicate that the active learning strategy enhanced the performance of 38 (69%) students. For the second part of this quantitative method, the Dadach Motivation Factor 'DMF' was introduced in order to measure the effects of the active learning strategy on the motivation of students. Based on the requirement of the analysis (DMF > 1), the final results suggest that the active learning strategy has enhanced the motivation and increased the performance of twenty-two (40%) students. On the other hand, motivation did not have a significant role for the other sixteen (29%) students whose performance in the process control course (FGP) was higher than their average performance in the department (CGPA). The results of the quantitative approach were compared with the student survey.

Keywords: active learning; student's performance; Dadach Motivation Factor

1. Introduction

Most freshmen in engineering departments associate an equation learned in a course with a unique theory specific to the subject and they fail to realise that it is part of a more general notion that can be applied to a wide variety of natural phenomena. The students are able to use formulae related to the theory perfectly, but sometimes fail to understand what the basic concepts hidden behind the applications are. As a result, many students do not know how to apply similar formulae in other courses in the department. On the other hand, engineers are problem solvers; they need good critical and creative thinking skills to increase the performance of a process or design a new plant under technical, social, economic, regulatory, and environmental constraints. So how can engineering students be taught to achieve these goals? Literature has shown that effective teachers succeed in making students feel good about school and learning, thus increasing student achievement [1]. According to Michel *et al.* [2], students in an actively taught class learn (memorise) the material to which they are exposed better than those taught passively. Olson [3] also stated: 'Motivation is probably the most important factor that educators can target in order to improve learning.'

2. Active learning methodology

According to Williams and Williams [3], to improve their motivation, students must have access, ability, and interest, and must value education. The teachers must be well-trained, must focus and monitor the educational process, be dedicated and responsive to their students, and be inspirational. The content must be accurate, timely, stimulating, and pertinent to the students' current and future needs. The method or process must be inventive, encouraging, interesting, and beneficial, and provide tools that can be applied to the student's real life. The environment needs to be accessible, safe, positive, personalised as much as possible, and empowering. In the same perspective, Case and Fraser [4] recommended reducing content coverage, promoting active learning in the classroom, and using assessment methods that require students to demonstrate a high level of understanding and ability. For example, Turner and Patrick [5] examined how a mathematics student's work habits (i.e., classroom participation) are related to a combination of both student factors (maths achievement, personal achievement goals, perceptions of classroom goal structures, and teacher support) and features of the classroom context (teachers' instructional practices and average perceptions of classroom goal structures). Their study provided some evidence that teachers' instructional behaviour can contribute to the development of students work habits by encouraging and supporting them to participate in classroom activities.

Active Learning is generally described as a process in which students engage in doing things and thinking about what they are doing in the classroom [6]. Active learning includes a variety of activities, such as pausing in lectures for students to consolidate their notes, interspersing short writing exer-

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cises in class, facilitating small group discussions within the larger class, incorporating survey instruments, quizzes, and student self-assessment exercises into the course, leading laboratory experiments, taking field trips, and using debates, games, and role plays [6, 7]. Some of the benefits of active learning are: (a) students are more involved than in passive listening; (b) students may engage in higher order thinking, such as analysis, synthesis, and evaluation, and (c) student motivation is increased [6]. In addition, Hattie [8] and Marzano [9] have independently used statistical methods to average the findings of many thousands of the most rigorous studies on active learning. Their findings show that, for the best active methods, if a student is put in the active learning group then, on average, they will do more than a grade and a half better than if they had been placed in the traditional learning group. To support the efficiency of the active learning strategies, Fig. 1 shows that students could retain up to 90% of what they learn through direct experience.

Since engineering students need to work with real process applications, charts, diagrams, hands-on practice and demonstrations concurrently with theory, equations and words, they are encouraged to become active rather than passive learners by developing collaborative and cooperative skills, and lifelong learning skills [11, 12]. In recent years, the Accreditation Board for Engineering and Technology (ABET) has increased the pressure on engineering schools to produce graduates who are prepared to engage in unstructured problem solving and to work in groups. Indeed ABET now requires institutions to demonstrate that their graduates have developed eleven competencies, including the abilities to design a system, component or process to meet certain needs, to function in multidisciplinary teams and to communicate effectively [13]. In group-work activities, engineering students have the opportunity to learn from and to teach each other when applying a newly learned concept in a short application such as problem solving. Group activities include design projects, in-class presentations, computer simulations, and lab experiments [13–15]. For example, Niekerk *et al.* [16] used Pair Problem Solving (PPS), a cooperative learning strategy, to enhance the conventional teaching method used in Thermodynamics, a third year module in the Mechanical Engineering curriculum. During the interviews, an important indicator of the success of PPS is that a large majority of students (80%) felt that they gained insight and knowledge from working in pairs. Eighty-seven percent of the students indicated that they would prefer to work in pairs again. Also, five of the six students were positive about working in pairs. The sixth student was already studying with a friend and was therefore not against working in pairs—only against the fact that she could not choose her partner.

Problem-Based Learning (PBL) is another active learning activity and has been considered by a number of higher educational institutions in many parts of the world as a method of delivery. Through PBL, engineering students can acquire creative thinking skills and professional skills as they tackle complex, interdisciplinary and real life problems. PBL has also been linked with increased student motivation and interest in a subject [17].

Another effective teaching style that could enhance the students' intrinsic motivation and achievement is to adopt a deep approach to learning by trying routinely to relate course material to known situations. Many science and engineering teachers successfully used analogies to build conceptual bridges for students between what is familiar (an analogy concept) and what is new (a target

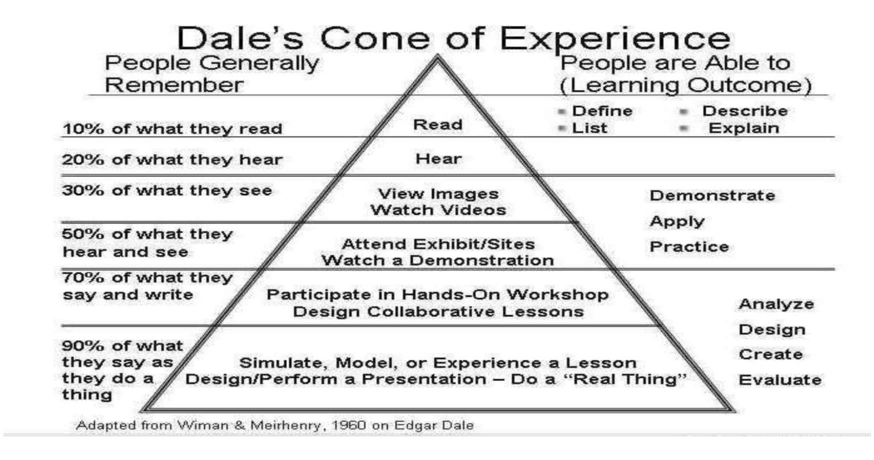

Fig. 1. Dale's Cone of Experience [10].

concept) [18–22]. According to Yelamarthi *et al.* [23], some of the immediate positive outcomes in using analogies are increased student motivation, better participation in class and laboratory exercises, better rapport between the student and instructional group, increased creative thinking of the students and active student participation in providing valuable course feedback. Finally, open-ended questions are also a useful tool to promote creative thought, problem solving skills, and the cognitive abilities of engineering students because they inherently build a stronger bond with better memory and a more engaged conversation [24].

3. Measuring student learning outcomes

There are many ways to collect evidence of student learning. To simplify the options, assessment efforts are categorised as direct and indirect measures. According to Maki [25], direct methods prompt students to represent or demonstrate their learning or produce work so that observers can assess how well student texts, responses and skills fit program level expectations. The strength of direct measurement is that faculty members are capturing a sample of what students can do, which can be very strong evidence of student learning. A possible weakness of direct measurement is that not everything can be demonstrated in a direct way, such as values, perceptions, feelings, and attitudes [26]. Some typical examples of direct measurement done by faculty include [26]:

1. Grades
2. Standardised tests
3. Pre/Post tests
4. Analysis of assignments designed to test conceptual understanding (e.g., concept maps, pro/con grids)
5. Observations of students performing a task
6. Analysis of student work products (e.g., exams, essays, oral presentations)
7. Senior thesis
8. Portfolios compiled over the course of undergraduate study.

Indirect methods capture students' perceptions of their learning and the educational environment that supports that learning, such as access to and the quality of services, programs, or educational offerings that support their learning [25]. Typical examples of indirect measures of learning outcomes done by faculty include [26]:

1. Grades
2. Course evaluations (during the semester and end-of-semester)
3. Concept questions, 'muddy cards' and other in-class techniques
4. Surveys of student attitudes about new pedagogy, curriculum, etc.
5. Surveys asking students for reflections on their learning
6. Exit interviews.

Grading is the process by which a teacher assesses student learning through classroom tests and assignments, the context in which teachers establish that process, and the dialogue that surrounds grades and defines their meaning to various audiences. As a consequence, grading could have four different roles: (a) evaluating the quality of a student's work; (b) communicating with the student, as well as employers, graduate schools and others; (c) motivating how the students study, what they focus on, and their involvement in the course and (d) organising to mark transitions, bring closure, and focus effort for both students and teachers [27]. According to Breslow [26], grades provide a measure of how much students have learned. However, the validity of grades as an assessment measure is dependent upon how systematically and rigorously assignments, exams, and so forth, are analysed for evidence of Student Learning outcomes (SLOs).

As an indirect measure of SLO, student surveys have become increasingly important tools for understanding the educational needs of students. When combined with other assessment instruments, many departments have successfully used surveys to produce important curricular and co-curricular information about student learning and educational experiences [28]. The different indirect measures can provide additional information about what students are learning and how this learning is valued by different stakeholders. However, as evidence of student learning, indirect measures are not as strong as direct measures because we have to make assumptions about what self-reporting actually means [29]. Because each method has its limitations, an ideal assessment program combines direct and indirect measures from a variety of sources. This triangulation of assessment can provide converging evidence of student learning [29].

4. Measuring the effects of an active learning strategy on the performance of students in a process control course

4.1 Introduction of the course

Process Control is applying the principles of automatic control within the process industries. It implies that two disciplines are involved: Chemical Engineering and Control Theory. The process control course (CHEM N 304) described in this paper is a four-hour lecture course offered during the winter term to the third year students of the Chemical

Engineering Department of Abu Dhabi Men's College (UAE). The course has forty sub-learning outcomes within seven distinct learning outcomes and was taught to fifty-five students divided into three sections.

4.2 The different active learning strategies used

Since engineers are mainly involved in solving technical problems or innovating new processes, critical and creative thinking skills need to be developed. In order to reach this objective and enhance the intrinsic motivation of the students, the teaching style was based on active learning [6]. The objective of the use of this strategy was to help students make relevant connections between course materials, transforming them from opaque language into something that they could visualise and integrate into their own knowledge network. In this perspective, a workbook was given to the students during the first class. This workbook provided relevant material being covered in the lectures, worksheet exercises, case studies and labs that offered opportunities to build upon knowledge and apply basic process control principles. The teaching strategy included the use of analogies, interactive, cooperative, and inductive learning techniques.

4.2.1 Analogies

Since students were not familiar with control theory, it was beneficial to use as many analogies as possible to explain the basic concepts of control theory. The final aim of using analogies was to give students different ways to visualise the abstract concepts of control theory that could help them understand better the physical phenomena hidden behind each equation in order to perform the calculations properly. The analogy between process control systems and brain/body interactions was extensively used to help the students create a link between what they already know about brain/body mechanisms and the sophisticated concepts of control theory.

4.2.2 Interactive classroom

(a) During the first half hour of the first class of each week, students were asked to answer questions related to the previous lecture. A discussion between the students was encouraged and a final conclusion that clarified the key points of the precedent chapters and connected the students with the new topic was also presented.

(b) Secondly, in order to encourage curiosity to discover the unknown, all the questions about the new lectures were open-ended questions. In this perspective, the question 'Why?' was very often used. In their smiles, I could guess that some students accepted the challenge to think deeply about the topic to formulate answers. In addition, the question 'What happens if. . .?' was used instead of the question 'Do you have any questions?'. The discussion with the students generally provided an indication of their level of understanding of the material.

(c) Finally, to grasp the concepts better, five videos (20 minutes each) with exercise books were used whenever students lost some focus and it was needed to recreate images in their mind that could help them follow the difficult theory of process control. Very often, videos had to be stopped and students were asked open-ended questions for general discussions about the key points of the subject covered. After each video, students were asked to work in groups to fill in the blanks in the corresponding exercise book. Students were also invited to review these videos at their convenience as often as they wished.

4.2.3 Cooperative learning

Class activities of two hours were usually organised after three or four lectures. As defined in the literature [31], class activities were based on Pair Problem Solving (PPS), a cooperative learning strategy. Through PPS, three or four students had opportunities to explore and solve problem situations. They were encouraged to use whatever solution strategies they wished. Students were also given opportunities to share their various strategies with each other and decide together about the best solution to solve short problems or the selected options for more complex process control situations.

4.2.4 Inductive learning

Six lab experiments (two to demonstrate and four to conduct experimental investigation in groups of three students) were part of the active learning strategy to help students to understand in depth the theory of process control and learn how to apply it. Lab experiments in this course were meant to help students to work in teams and teach them how to carry out experiments in a safe manner, collect data using an investigative strategy, analyse experimental values and compare them with theory, present results in a professional manner and learn to use process control software tools.

4.2.5 Individual project

Problem-Based Learning (PBL) is another activity used in the active learning strategy. The objective of the project was to encourage curiosity and hunger for exploration in students by using all the library resources to search for the latest technologies and applications of process control for a specific application.

4.3 The assessment strategy

In this process control course, a variety of assessments were used throughout the semester-long course. First, two written exams (30 marks and 2-hour exams) were organised in the middle and the end of the semester respectively. Secondly, the assessment of the active learning strategy (lab experiments, cases studies, and project) represented 40% of the total mark. The non-exam activities that were assessed are:

(a) Team-work as Pair Problem Solving (PPS) (10 marks)
(b) Inductive learning (20 marks)
(c) Individual final project as Problem-Based Learning (PBL) (10 marks).

In conclusion, the assessment strategy used in this process control course is shown in Table 1.

Table 1. Assessment strategy of the course CHEM N 304

Activities	Mark for each activity
Labs: 3 and 4 (Individual reports)	10
Case studies (Group report)	5
Exam 1	30
Labs: 5 & 6 (Individual reports)	10
Case studies (Group reports)	5
Project (Individual report)	10
Final exam	30

4.4 Quantifying the effectiveness of the active learning strategy

A quantitative method was used in order to investigate the effects of the active learning strategy on the performance and motivation of students. The results of the student surveys were compared with the results of the quantitative approach. The investigation is based on the following assumptions:

1. The grade obtained for each activity in Table 1 is taken as an indicator of student achievement for the learning outcomes covered by the corresponding assessment. Since students had been assessed on different activities that covered all the learning outcomes, the final grade of a student can then be used as a direct measure of his average achievement for the process control course.
2. The fifty-five students took the same thirty-five (35) courses of three credits including twenty-six (26) technical courses (74%). Consequently, it is assumed that the Cumulative Grade Point Average (CGPA) of all the courses provided by the college is a good approximation of the average performance of each student for the technical courses taken in the department.
3. It is assumed that no external factor (family, health, etc.) affected the performance of the students.
4. As presented in Table 2, the grading system of the college is the reference for this investigation.

Table 2. Grading system of the college

Grade	Range	Grade Point (GP)
A	90–100	4
A^-	85–89	3.7
B^+	80–84	3.3
B	75–79	3
C^+	70–74	2.3
C	65–69	2
D	60–64	1
F	0–59	0

4.4.1 Relative performance of each student

The goal of the first part of the quantitative analysis is to compare the performance of each student in the process control course with his average performance related to all the courses taken in the department. For this purpose, Equation 1 is presented in this paper as a tool to define, in percentage, the relative performance *RP* of each student:

$$RP = \frac{(FGP - CGPA)}{CGPA} \times 100^\circ \qquad (1)$$

A positive or a negative value of the RP means that a student performance in this process control course was higher or lower than his average performance for all the courses taken in the department. The distribution of the performance of all students is shown in Fig. 2.

The overall analysis of Fig. 2 indicates that 38 students (69%) had a positive RP. Figure 2 shows also that the highest values of the positive RPs are located in the lower CGPA region. This finding could be explained by the fact that it is easier for students in the lower CGPA region to increase their grade. Finally, the sum of the positive and negative relative performances of all the students indicates that, on average, every student had a positive RP of +6.86%.

4.4.2 Quantifying the impact of motivation on the performance of students

Research has shown that motivation influences student involvement and academic achievement [32]. The measurements of student motivation presented in the literature are either through an assessment of the amount of time that students freely spent on an activity or by using tools such as

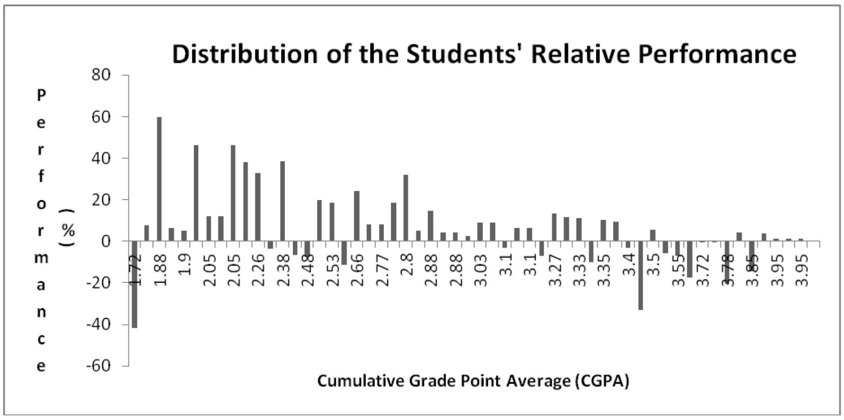

Fig. 2. Relative performance of each student in relation to their Cumulative Grade Point Average (CGPA).

questionnaires and interview [33]. Surveys are the most common tools used to measure motivation. Typically students answer a list of potential questions on motivation [34–37]. For example, Vroom's theory was used by Lanigan [38] to define the *Motivational Force* as the product of *Valence*, *Instrumentation* and *Expectancy*:

$$\textit{Motivational Force } (MF) = \textit{Valence} \times \textit{Instrumentality} \times \textit{Expectancy}, \tag{2}$$

where *Valence* refers to the emotional orientations that people hold with respect to outcomes [rewards]. *Instrumentality* is the perception of students expressed as a probability that there will actually be an outcome associated with completing the assigned task and *Expectancy* refers to the different expectations and levels of confidence about what the stuidents are capable of doing. The two selected populations of students were college students who have chosen Industrial Engineering as a major and middle school students with a predisposition toward engineering. Pre and post surveys were used to measure whether students' motivation to pursue Industrial Engineering increased over the course of the year. Based on the results, recommendations were made to increase *Valence*, *Instrumentality* and *Expectancy*.

Savage and Birtch [39] examined the motivation of a group of students in the Department of Electronic and Computer Engineering at the University of Portsmouth. The objective was to measure the 'intrinsic' and 'extrinsic' motivation of students by employing qualitative data-gathering methods, including questionnaires and semi-structured interviews. The results indicated that many at the Department of Electronic and Computer Engineering at the University of Portsmouth operate intrinsically. Such a finding suggests that students might benefit from more loosely specified assignments such as giving them freedom to choose from their laboratory work and assignments aspects in which they have a greater personal interest [39]

Mentzer [40] investigated whether high school students' academic preparation was correlated with change in motivation during an engineering design challenge (a team-based activity). Participant motivation was assessed by the California Measure of Mental Motivation (CM3). The CM3 is a qualitative survey that measures student motivation to apply critical thinking skills and reasoning to solve problems in five subscales: mental focus, learning orientation, creative problem solving, cognitive integrity and scholarly rigour [40]. The Grade Point Average (GPA) was used in the study as a reference to measure the diverse academic backgrounds of students. The findings suggested that knowledge of student GPAs served as a predictor of student motivation [40]. Other independent research works showed that GPA is a significant predictor of engineering student success [41, 42].

However, according to Ray [39], the traditional methods of attempting to measure motivation by questionnaires and interviews are prone to giving inaccurate results because it is easy to fake a response to the questions. Ray promotes the concept that motivation can be assessed by using a questionnaire in which it is not easy to predict what is being measured [40]. Unlike the methodologies presented in the literature, the objective of the second part of this investigation is an attempt to quantify the impact of an active learning strategy on the motivation of students by introducing a motivation factor (MF) for each student calculated from his Final Grade Point (*FGP*) and his Cumulative Grade Point Average *CGPA*. To reach this goal, the general formula of transport phenomena is used:

$$\textit{Flow} = \frac{\textit{Driving force}}{\textit{Resistance}} \tag{3}$$

For example, in Ohm's law, the current I (flow of electrons) is motivated by the difference in potentials ΔU and controlled by the electrical resistance, R, of the circuit:

$$I = \frac{\Delta U}{R} \tag{4}$$

Using an analogy with Ohm's law, what the students learn could represent the 'Flow' of information from the teacher (the source of knowledge). It is also assumed that a student having a low CGPA could present a higher 'Resistance' to receiving the information and, as a consequence, to his motivation and performance [40–42]. Since nothing can be done about the student's background (CGPA), the active learning strategy was used to enhance the driving force 'ΔU' in order to increase the 'Flow' of information. However, unlike electrical resistances in parallel that all receive the same ΔU, students in the same classroom learn differently and, as a consequence, are differently motivated by the same teaching strategy. Based on this assumption, this paper introduces the motivation factor (*MF*) of a student as his specific 'ΔU' related to the effects of the active learning strategy on his motivation to increase the 'Flow' of information. In this particular situation, the 'Flow' of information could be approximately represented by the Final Grade Point (*FGP*), which was assumed to be a direct measure of student performance. It is also assumed that the 'Resistance' to the learning process is equal to the inverse of the Cumulative Grade Point Average (CGPA). Based on Equation 4, the motivation factor (*MF*) is the ratio between the Final Grade Point (*FGP*) and the Cumulative Grade Point Average (*CGPA*):

$$MF = \frac{FGP}{CGPA} \tag{5}$$

Table 3. Correction factor α for the motivation factor

Grade Point (GP)	LM (Lowest Mark)	α
4	90	0.9
3.7	85	0.92
3.3	80	0.97
3	75	1.0
2.3	70	1.22
2	65	1.3
1	60	2.4
0	0	∞

Equation 5 could be used as a simple approximation to estimate the motivation factor (*MF*) of each student. However, Table 2 shows that the motivation factor decreases when the *CGPA* increases. As shown in Table 3, a correction factor α is introduced and assumed to be equal to:

$$\alpha = \frac{LM}{25 * GP} \tag{6}$$

Using Equation 6 and Table 3, Equation 5 is rectified in order to obtain a common scale for the motivation factor (*MF*) by adjusting its values according to the different values of α. As a result, the Dadach Motivation Factor, *DMF*, is calculated using the following equation:

$$DMF = \frac{FGP}{\alpha * CGPA} \tag{7}$$

Values of the *DMF* higher than unity mean that the effects of the active learning strategy on the motivation of the students were significant. It is assumed that a Dadach Motivation Factor is equal to unity if $0.98 < DMF < 1.02$. To the best of my knowledge, Ohm's law has never been presented in the literature as a tool to estimate the effects of a teaching strategy on the motivation of students. Based on Equation 7, the graph for the Dadach Motivation Factor is used

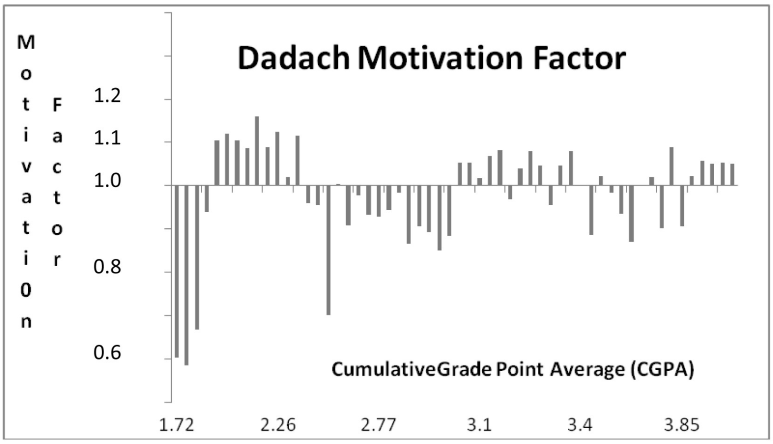

Fig. 3. Dadach's graph for motivation.

to analyse the effects of an active learning strategy on the motivation of students.

As shown in the DMF graph, twenty-two students (40%) had a motivation factor higher than unity. It could be concluded that these students were motivated by the active learning strategy. Moreover, students having a *CGPA* lower than 1.9 had the lowest values of the Dadach Motivation Factor. This result could be related to the fact that it was difficult to motivate this category of students. Finally, students having a CGPA of letter grade C ($2 < CGPA < 2.3$) had the highest values of the Dadach Motivation Factor. As a consequence, motivation played an important role in the positive performance of these students (Fig. 2). The comparison between the results related to the performance (first part) and the motivation (second part) of students is shown in Table 4.

First, the twenty-two (40%) students with a Dadach Motivation Factor higher than unity also had a positive relative performance. The performance of these students is therefore due to their high level of motivation. Secondly, five of the six students who had a DMF equal to unity, had a negative relative performance. However, the values of their RP are small ($RP \approx -5\%$). These students could be considered as slightly motivated by the active learning strategy. Finally, fifteen (27.3%) students had a positive relative performance but a Dadach Motivation Factor lower than unity. Therefore, their performance in the process control course was not due to their motivation to learn.

4.5 Qualitative measurement of the active learning strategy

Student satisfaction surveys are commonly used in higher educational institutions as a feedback mechanism to determine the quality of the delivery of education. They are designed to encourage action for improvement, which forms part of the accountability procedures at the institution. Nowadays, one of the most common scaled-response format questions in student satisfaction survey design is the Likert scale. At the end of each semester, a qualitative measurement of student satisfaction, in which students have to complete an online course satisfaction survey based on a Likert scale, is given by the college administration. The students answered the survey one week before the final exam. The findings of the survey related to the present process control course are shown in Table 5. The answers for the selected questions are tabulated as: 1–Strongly agree, 2–Agree, 3–Neither agree or disagree, 4–Disagree, 5–Strongly disagree.

First, the high level of satisfaction of the students for the active learning strategy used in this process control course is clearly shown by the fact that almost all questions were rated as ‘Strongly agree’ or ‘Agree’ and 86% of them were highly satisfied with the teaching overall (Question 14). The success of the active learning strategy is also shown by the positive feedback of the students for the questions related to the different activities used: Question 9 (93% Strongly agree), Question 10 (86% Strongly agree) and Question 6 (79% Strongly agree). The

Table 4. Combined results for the Relative Performance (*RP*) and Motivation Factor (*DMF*) of students

	DMF > 1.0		**DMF = 1.0**		**DMF < 1.0**	
	RP > 0	**RP < 0**	**RP > 0**	**RP < 0**	**RP > 0**	**RP < 0**
Frequency	22 (40%)	0 (0%)	1 (1.8%)	5(9.1%)	15 (27.3%)	12 (21.8%)

Table 5. Student satisfaction survey of the process control course

		Student feedback			
Question number	**Question**	**1**	**2**	**3**	**4 and 5**
1	(The teacher) Gives me activities that suit the way I like to learn	50%	50%	0%	0%
2	Helps me understand how I can do better	57%	43%	0%	0%
3	Shows me how what I learn links to everyday life	79%	21%	0%	0%
4	Motivates me to learn	79%	21%	0%	0%
5	Respects me	100%	0%	0%	0%
6	Helps me take responsibility for my own learning	79%	7%	14%	0%
7	Is interested in helping me learn	79%	7%	14%	0%
8	Encourages me to participate actively in class	86%	14%	0%	0%
9	Uses a variety of resources to help me learn	93%	7%	0%	0%
10	Gives me activities where sometimes I work in groups and sometimes by myself	86%	14%	0%	0%
11	Is able to answer my questions about the course	79%	14%	7%	0%
12	Always lets me know how well am I doing in the course	57%	36%	7%	0%
13	Explains the course content clearly	86%	14%	0%	0%
14	Overall I am satisfied with my teacher	86%	14%	0%	0%

lowest percentage (50%) of the student survey obtained for Question 1 (Gives me activities that suit the way I like to learn) shows that the learning strategy did not fit the way that some students wanted to learn. In accordance with the students' survey, the results of the first part of the investigation showed that 38 (69%) students benefited from the active learning strategy and had a positive relative performance. For the question related to motivation, 79% of students strongly agreed that they were motivated to learn (Question 4). However, the results of the quantitative method indicated that only 40% of students had a Dadach Motivation Factor higher than unity. Therefore, the feedback of 21 students (39%) does not fit the requirement of the quantitative method.

5. Conclusions

The success of the active learning strategy can be proved by the fact that the performance of 38 (69%) students was higher in the process control course than their average performance in the department. According to the student survey, 79% of the students were highly motivated to learn, however, the graph corresponding to the Dadach Motivation Factor indicates that the active learning strategy motivated only twenty-two (40%) students to have a positive relative performance. The performance of the sixteen (29%) students, who had a positive RP, does not correspond to the requirement of the quantitative analysis based on the Dadach Motivation Factor higher than unity. It could be assumed that the performance of these students was within the limits of their capacity to perform. Consequently, motivation did not have a significant role in obtaining their grade.

In conclusion, this new method provided useful results regarding the effects of an active learning strategy on the motivation of students. These preliminary findings encourage the exploration of a broader scale in a future investigation where this methodology will be further studied by comparing the results of the quantitative analysis to student surveys (Likert scale) on the performance and level of motivation of students.

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